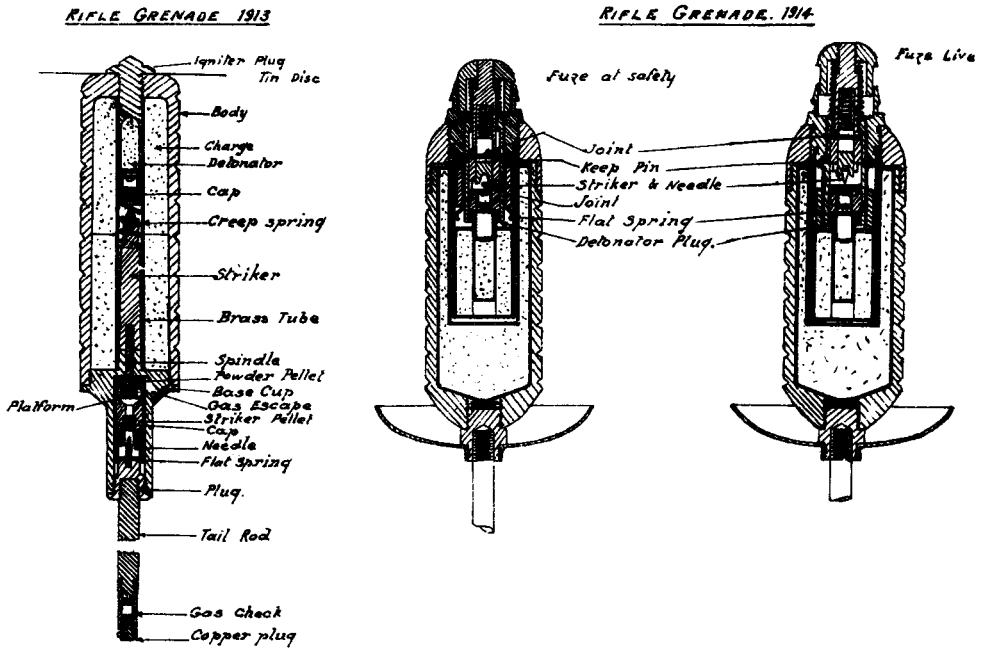
CHAPTER 6

Rods and Phosphorus – Rifle Grenades and Chemical Grenades 1914–18

For about the first two years of the war, the development of rifle grenades followed much the same pattern as that of hand grenades; in other words it was piecemeal, with the overriding necessity of expedience governing supply. Moreover, their development progressed independently of hand grenades for much of the time despite the introduction of a rifle-launched version of the Mills and a growing realization that a grenade was needed that could be thrown as well as rifle launched without the need to convert it with attachments. Rather than becoming more streamlined from then on, the development of rifle grenades grew more complex because there were now several lines of enquiry which were followed by several different departments which did not always confer or cooperate.

The first rifle grenades were rodded, the rod being inserted down the barrel of the service rifle. With the continued development of the Mills, it was found that by fitting it with a rod it too could be fired from a rifle. However, in order to do this a means of retaining the lever after the pin had been removed had to be devised and this resulted in the first grenade cup attachment. This led to the development of cup dischargers which obviated the need for rods altogether but, rather than superseding rodded grenades entirely, both sorts remained in service and rodded grenades were still being developed when the war ended. To complicate things further, the cups themselves had to be developed; then there was the percussion fuse; and finally the development of an entirely new sort of grenade discharger or gun was also pursued. This last weapon was a radical departure from the standard munitions, being something that could be fired from the shoulder and dedicated solely to grenades – small arms ammunition could not be fired from it.

There was much to be said for the rodded rifle grenade, most of it concerned with its simplicity, although in terms of its construction the earlier ones were far from simple. However, the basic means by which they were fired from the rifle was. This simplicity dominated thinking about rifle grenades for a long time despite the fact that their disadvantages were considerable. For one thing, the rods were inconvenient for the rifle grenadiers. The rods were additional weight that had to be carried and because they were long they tended to snag on things. Worse than this, they were very bad for the barrel which tended to bulge and eventually split. The propellant gases hit the end of the rod at extremely high velocity and were reflected back down the barrel. This caused a reflected pressure wave. The shorter the rod, the greater the velocity of the gases because they travelled further up the barrel before meeting the end of the rod, and the greater the pressure of the reflected wave. The increase in pressure in the barrel was enormous and it could only stand just so much before the metal failed. Burst barrels were a common hazard. There was also the danger that the rod could jam in the barrel.

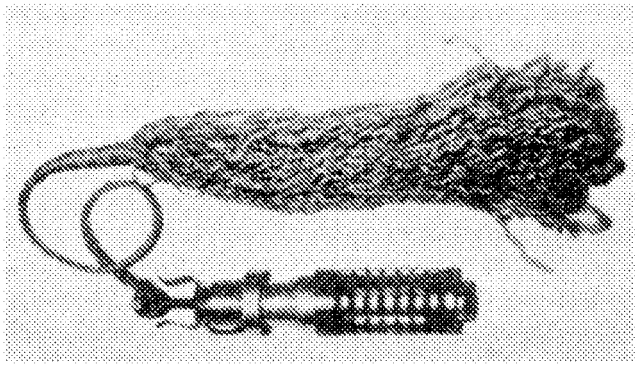


German rifle grenades from the early part of the war. The 1914 model contained less explosive than the 1913 model and its live condition was more easily recognizable, which was fortunate because the fuse was extremely sensitive. In The Training and Employment of Grenadiers *of October 1915 it was noted that damp rods should be dried prior to use and if a rod did not slide easily into the barrel on no account was force to be used; the rod should be discarded if it did not fit. Such caveats applied equally to British rifle grenades.*

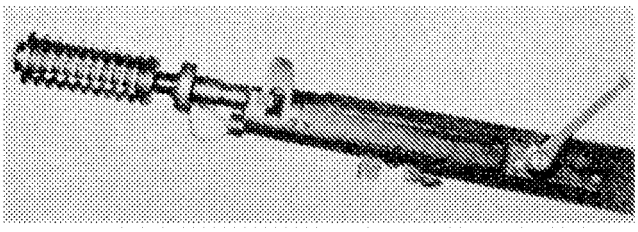
If that were not bad enough, the whole rifle could shake itself apart with the recoil which tended to be far greater than when normal small arms ball ammunition was fired. When a rifle grenade was fired, the butt of the rifle was held against the ground which resisted the recoil. Whereas short rods caused the barrel to split sooner than long rods, long rods allowed the gas pressure to be exerted on them for longer because it took them longer to clear the muzzle. Although this increased the velocity of the rodded grenade and therefore extended the range it also had the disadvantage of increasing the recoil. In a relatively short time, the rifle could break up because it was stressed beyond its limits. Of course, when the war started none of this was known.

Unlike the Germans, the British only adopted a rifle grenade after the outbreak of war when it became apparent that such things were a necessary evil. In 1914 the German Army was equipped with the *Gewehrgranate* 1913 and 1914 models. These, like all early rifle grenades, were rodded. The 1914 model had a complex percussion mechanism which was armed by inertia when the grenade was fired from the barrel. A special cradle or frame was used to support the rifle, turning it, in effect, into a mini trench mortar. Complexity was also a common problem with the first British rifle grenades. The No. 3 Mk I Hale rifle grenade was a complicated piece of precision engineering and as a consequence was very expensive to manufacture. When there was an urgent need for as many rifle grenades as possible, this was a distinct disadvantage that reduced the supply.

Its predecessor, the No. 2, was an interim measure supplied from the Cotton Powder Company contracts for Mexico. Because of its origins it was also known as the 7 mm or Mexican pattern. This was essentially the same as the hand-thrown version except that it had a steel rod attached to the base and a two-pronged clip or clutch which engaged the muzzle and held the grenade in the barrel. It was fired by a blank cartridge. As well as commandeering the grenades already in stock, an order was placed for more in August 1914. By September 1915 Roburite & Ammonal were also involved in making the grenade. A slightly different model intended to be fired from 8 mm rifles was also supplied from the existing stock. These had no clip, presumably because the rod was a tight fit in the barrel whereas the 7 mm model was a loose fit and needed a clip to make sure that the grenade did not slip out. Clearly, as stopgap measures they were better than nothing but they left a great deal to be desired.



A No. 3 rifle grenade adapted to be thrown by swinging the rope handle. (ILN)



A No. 3 fitted in the barrel of an SMLE with the clip round the muzzle, summer 1915. The pin is still in place. Note the special sight attached to the side of the fore-end. (ILN)

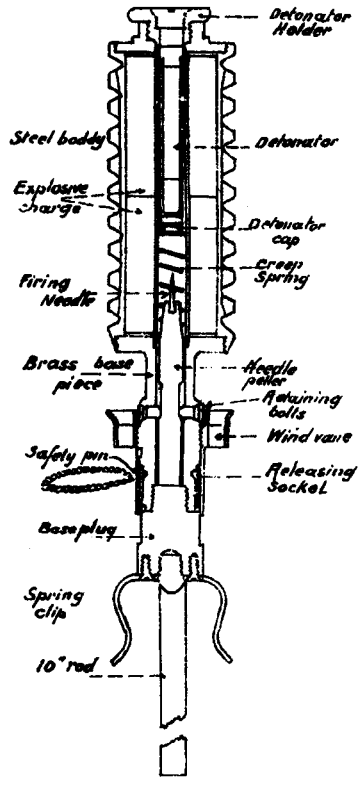
Nevertheless, the No. 2 remained in service well into 1915. The problem of securing an adequate supply of detonators for this and the No. 3 has been discussed elsewhere (*see* Chapter 1) and in an effort to resolve this the Trench Warfare Department and the Woolwich Arsenal started to look at new designs. Even in late 1915, the possibility of redesigning the grenade so that it could use a different detonator was looked on as an undesirable course of action. This was partly because the process would take too long to solve the immediate problem. On 27 August 1915 Field Marshal French had asked for 112,000 rifle grenades a week but by October the supply was still only 19,000 a week (mostly No. 3s), although output was increasing because of the pressure the Trench Warfare Department brought to bear on the contractors.

A proposal to use a different explosive, Tonite, in the No. 3, put to the Chief Inspector at Woolwich to increase production was eventually accepted (the grenade was then designated the Mk II). The Trench Warfare Department predicted that this would increase production by 75 per cent. However, it was not unusual for a platoon to be issued with no more than six No. 3 grenades for an entire tour of trench duty. Considering that the Germans were amply supplied and using them in considerably larger numbers than this, six per platoon was pitiful. Fortunately, the situation changed. By the time of the Somme in July 1916, there were enough for the Royal Welch Fusiliers to expend thousands in a matter of a few hours during a retaliatory raid by two reinforced companies on German positions.

The No. 3, also known as the J pattern and the Hale pattern, was the first wartime design. It was similar to the No. 2 and although it quickly followed the latter into service, trials continued well into 1915 to improve on it and find the most suitable length of rod. Eventually, the grenade went through several changes resulting in a total of eight different marks (No. 3 Mks I, I*, II, II*, III and No. 3A Mks I, I*, II). The differences were minor for the most part, the most significant being more streamlined contours and different explosive fillings.

The body of the No. 3 was machined from a solid steel cylinder and had the customary 'serrations' for fragmentation. A brass base piece was bored out to take the striker (a sharply pointed steel needle) in the top and was screwed into the body. The bottom of the base piece was machined to take a circular wind vane and, below the boss of the vane, a check was also machined on it. Over this was fitted a safety socket that had been machined so that it was a tight fit over the check and was flush with the boss. This prevented the vane from unscrewing and held the striker retaining bolts in place (these extended radially into the striker and prevented it from moving forward). A plug was screwed into the bottom of the base piece, machined with a screw thread to take the steel rod. The detonator and a three-grain

This shot allegedly shows rifle grenade practice but it is posed for the camera. To fire the grenade, the butt of the rifle had to be held firmly against the ground because of the recoil. It would be highly dangerous to fire a grenade while holding a rifle in both hands like this. Moreover, because of the possibility of a premature at the muzzle, everyone in the photograph is taking his life in his hands if they propose to fire the grenades. (ILN)



The No. 3 rifle grenade. Grenadiers were warned not to launch the grenade with a bulleted round because this would burst the barrel. It was a safe grenade to handle as it was only armed in flight by the vane. (The Training and Employment of Grenadiers)

percussion cap were in the top of a central tube inside which the striker moved (from the bottom to the top). This tube was screwed into the top of the grenade and a brass retaining plug screwed over it.

Before the striker was inserted it was important to make sure that it was properly held by the retaining bolts. It was, unfortunately, quite possible to assemble the grenade with the striker in front of the bolts. If this happened, the act of inserting the detonator would be an act of suicide as the striker would immediately penetrate the cap. A simple way to check that everything was as it should be was to insert a pencil into the tube and see how far it went before touching the tip of the striker, then to compare that with the length of the detonator. There was supposed to be a clearance of 0.33–0.50 in. It was a foolish man who did not carry out this crude test. The cap was, itself, a potential hazard as it was powerful enough to cause serious injury, so it had to be handled with great care.

A report from May 1915 of a trial of the long rifle version of the grenade (the No. 11 which was essentially the same as the No. 3, except that it was intended to be fired from the older Lee Enfield and Lee Metford rifles) set down the correct procedure for loading and firing and stressed the importance of abiding by it.

1. Fit rod and secure it with the small securing screw.
2. Gauge with plug and fit detonator.
3. Insert rod in rifle and rest the butt on firm ground at the angle necessary for range.
4. Remove safety pin and pull back the safety pin collar [safety socket] to disengage it from the vane wheel.
5. Insert a round of special blank.
6. Fire.

It also stressed that all the rods should be tried in the barrel to make sure they fitted, before screwing them to the grenades to avoid potentially dangerous jams. It was possible that nickel fouling from firing small arms ammunition or a defective rod could cause a jam.

On firing the blank, the grenade was propelled from the barrel and the shock of discharge forced the safety collar back over the check, allowing the vane to be turned by the wind. This unscrewed, releasing the retaining bolts from the striker which was now free to move forward and hit the percussion cap when the grenade struck the ground.

It soon became apparent that the grenade had several weaknesses, not the least of them being the precision with which the components had to be made. This meant that production in quantity was practically impossible. Moreover, the vane was particularly troublesome as it was very difficult to align correctly and strong winds, rain or a single particle of dust could prevent the vane from working properly. The consequence of this defect in the design was a very large number of failures.

The obvious solution was to do away with the vane and make the safety socket longer so that it held the bolts in place until the shock of discharge forced it back, allowing the bolts simply to fall out. Not only was this a workable solution but it reduced the number of components. The first grenades to use the extended safety collar in place of the vane were converted No. 3s. The No. 20 vaneless grenade was the fruit of this evolution. It is not clear when the converted No. 3s and the No. 20 entered service but it was probably sometime in 1916. They suffered far fewer failures than the No. 3 Mks I and II. However, the No. 20 had a problem with the explosive filling. Neither pressed Tonite nor TNT pellets, used in No. 3, were readily available for the No. 20, so ammonal was initially used in their stead. This would have been a perfectly acceptable alternative but for the fact that it was a powder that

produced dust which got into the working parts of the grenade no matter what precautions were taken to prevent this happening when the explosive was loaded into the body. The ammonal powder corroded all the brass parts it touched. This, not surprisingly, affected the grenade's performance, defeating the improved mechanism and striker of the grenade. Like the No. 3, the body of the No. 20 was machined from a solid steel cylinder, the Mk I having the usual segmentation, while the Mk II was made from weldless steel tube and made do with milled circumferential grooves.

The next development along this evolutionary road was the No. 24 Mk I. This was intended, among other things, to solve the problem of prematures with the No. 3 and the No. 20 due to the powerful and sensitive percussion cap; it did not take much to set it off in flight. Sometimes, the grenade did not even manage to leave the rifle. Edmund Blunden came close to injury at the Harfleur Bull Ring when he first went out to France because of a premature at the muzzle. There was a 'strange hideous clang' as it exploded, killing the instructor and several others. A less sensitive and weaker cap was needed.

A waxed-paper container for the powdered ammonal was designed to overcome the dust problem. It was loaded with explosive in a building dedicated to just this purpose and the charged container was placed into the grenade body in another building. In this way, contamination was avoided but it was a tiresome additional step in the manufacturing process.

Ammonal is a mixture of ammonium nitrate and powdered aluminium – hence the name – and ammonium nitrate is sensitive to moisture, which in a European environment is a considerable nuisance since the humidity is such that there is nearly always moisture in the air. However, experiments showed that by warming the explosive to a particular temperature on special heating tables, it was effectively dried and the sealed waxed-paper container was found to be sufficiently moisture resistant to prevent the ammonal becoming recontaminated once it was inside the grenade. When it was contaminated by moisture it expanded, but now that a way had been found to prevent contamination, the expansion space was reduced which meant that the central tube which held the detonator and striker could be shortened to the minimum length. This not only reduced the manufacturing costs but improved the detonation of the grenade. Moreover, a less sensitive and less powerful cap could now be used and in combination with a blunter striker the problem of prematures was solved.

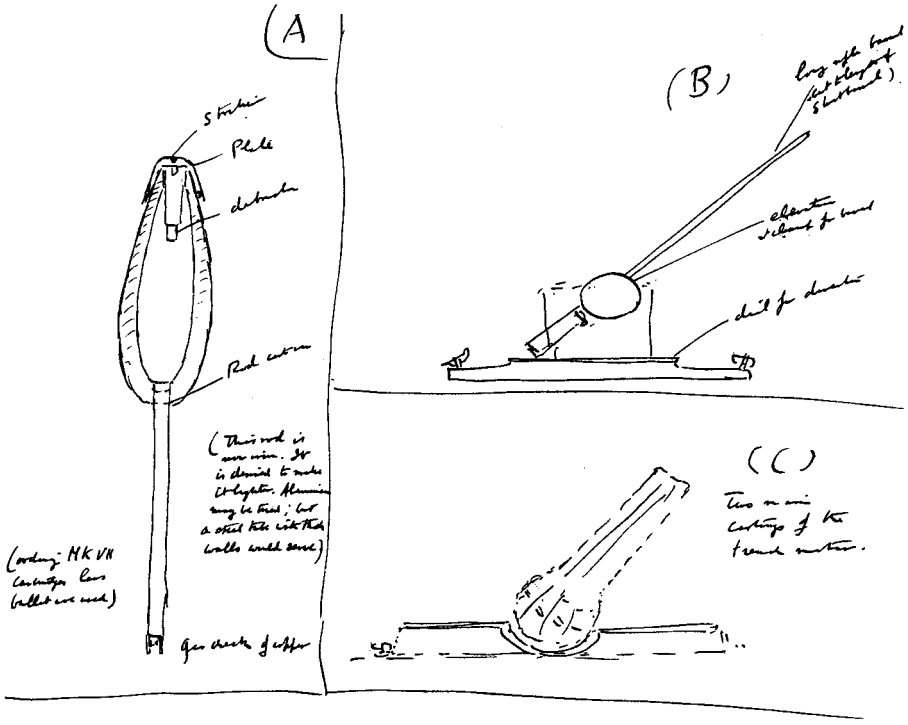
Further improvements were made with the adoption of cast iron for the grenade body instead of weldless steel tube. Cast iron had better fragmentation characteristics. The Mk II was made from cast iron without the circumferential grooves. This was not the end of the evolution process of the No. 3 as the No. 24 was developed into the No. 35, the final manifestation of the original No. 3. This was essentially the same as the No. 24 except that the detonator holder was a shortened small arms ammunition cartridge case and it had a slightly different base piece and a shorter striker. By the time the No. 35 entered service, it was 1918. The No. 3 percussion rifle grenade had been developed over four years from an expensive and unreliable munition into a much simpler and dependable weapon. For all that, it had been more a case of digging the same hole deeper than digging different holes in a search for water. Others took quite different routes to solving the rifle grenade problem and set about digging different holes.

Soon after Captain Newton set up the Second Army Workshop at Armentières, he designed a rifle grenade that was simple to make and much more reliable than the troublesome No. 3. His first grenade was a hand-thrown device but very little is known about it. The rifle grenade is documented much more fully. Confusingly, both are referred to as the Newton Pippin so it is possible that the rifle grenade was a development of the earlier hand grenade, or was simply the hand grenade with a rod. Production started in about June 1915 and eventually about three million were produced. After his visit to the workshop, Todhunter reported that although it

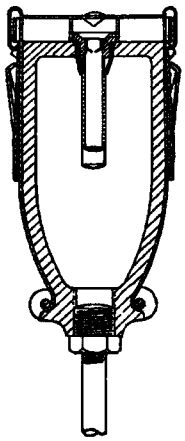
satisfied the demand for rifle grenades when the No. 3 was in short supply, it was not a device that was suitable for storage because of its firing mechanism, but noted that it could still be made in Britain if it was subsequently filled at the workshop. This suggestion was going to be taken up but when the grenade was compared with the improved rifle grenades of the No. 3 family it was considered to be inferior and production never started. So in the end, all Newton Pippins (designated the No. 22) were made in France. Some, apparently, were made in another workshop in Hazebrouck which seems to have been an outstation of the main one at Armentières.

The body of the grenade was a cone-shaped cast-iron cylinder with the 1.75 in diameter blunt end uppermost. The rod was screwed into the base which had a thread machined into it. Todhunter's report described it as having the sharper end uppermost and the rod being cast integrally. Although photographs do not support this description, it is unlikely that he was mistaken as he had discussed the grenade with Newton and had seen it being made. Since the grenade had not yet entered serious production, Todhunter may have seen a pre-production model that was subsequently modified. The rod was 15 inches in length and had a copper gas check on the end which was supposed to spread and seal the propellant gases behind the rod when the launching blank was fired. The gas check did not always perform as it was supposed to. Some were too stiff to spread while others were too fragile and broke, causing range discrepancies.

The grenade contained 2.25 oz of explosive which was fired by a shortened commercial No. 8 detonator inside a holder made from a standard 0.303 cartridge. The detonator sleeve was made from cardboard. Four lugs were cast on the outside of the body near the top. A



Captain Todhunter's rough sketches following his visit to the Second Army Workshop in 1915. 'A' is the Newton Pippin rifle grenade, 'B' is the rifle grenade launcher (see *Chapter 7) and 'C' is Newton's experimental 3.7 in mortar.* (WO 140/14)



Another Mills patent (109,066). This appears to be a development of the Newton Pippin. The white blocks above the body and beneath the cap are 'distance-pieces' to keep the striker away from the percussion cap, held in place by spring arms which pivot at the base of the body. These are held by a ring which is set back on discharge to free the arms which fall away, removing the distance-pieces.

loosely fitting cover made of plate steel with four side straps had a fixed striker riveted to the centre of it; the side straps snap-fitted over the lugs. Because the weight of the grenade was distributed well forward it always fell head first and the cover was driven back causing the striker to hit the cap. This surprisingly simple, almost home-made, rifle grenade was cheap, extremely effective and reliable although there was a problem with prematures at first due to the launching shock. A slight modification to the cover reduced the risk, however. Nevertheless, rifle grenadiers were instructed to fire the grenade from cover with the aid of a lanyard, standing about 6 ft away.

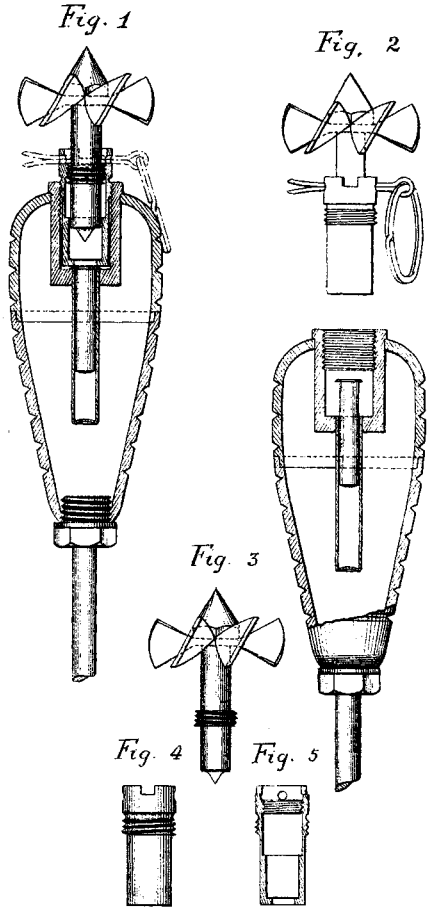
About 2 per cent of launchings resulted in the grenade exploding in the barrel although it had 'very little effect on the gun, beyond chipping the wood where the fragments strike'. The same could not be said for the grenadier if he was too close. Two possible explanations were mooted: the rod was driven through the grenade so that the detonator was forced into the striker; or the inertia of the cap and striker was enough to drive the latter into the detonator. Certainly, the casings were thin in the base area so the former was a distinct possibility, especially if a thin casing was combined with a badly made rod. However, tests to establish the primary cause of prematures was inconclusive. Newton believed that the prematures were caused by the inertia of the cap. He also blamed the use of safety pins which were imposed on the grenade by the Ordnance Board but he stopped using them and substituted a more closely fitting cap which seemed to resolve the problem.

An unexpected bonus was the fact that the grenade did not make a large crater when it exploded (it was about 18 inches in diameter and 6 inches deep in 'good stiffish clay' leaving the rod intact but for its screw thread). This was because of the instantaneous fuse which detonated the grenade before it had time to bury itself. This also meant that the grenade tended to explode even when it struck marshy ground. When it was fired at barbed wired entanglements it was found to destroy the wire without leaving a crater behind, one of the problems of shooting high-explosive artillery shells at wire; these were not fitted with instantaneous fuses, buried themselves on impact and produced craters that the infantry found difficult to cross in an attack. The fuse was subsequently adapted by the Second Army Workshop for use on the trench mortar bombs produced at the workshop so that the mortar rounds could be used for cutting wire. Sometimes, however, the grenade failed to detonate. This was often due to human error, such as failing to remove the safety pin first, rather than a defective design.

The Newton Pippin had a range of 250–300 yd when the rifle was elevated at around 45°, although a poor gas check could reduce the range to 220 yd while a very good one could extend it to 350 yd. This was about double that obtained with the No. 3. Because the muzzle velocity was about 200 ft per second, the flight of the grenade was easy to follow once it had

been spotted, according to a memo about the grenade, especially if the observer was 'about 100 yards away in a direction at right angles to the plane of the trajectory'. (Spotting a rifle grenade in the first place was, however, the tricky bit and for the most part the observer was more or less in a direct line of flight, not at right angles to it. Frank Richards and Robert Graves both agreed that they were hard to see. This was because they rose to a considerable height before descending and were practically silent.)

The grenade rotated slightly in flight and usually lay tangential to the trajectory but sometimes it slewed at right angles. This was attributed to the rod whipping as it left the barrel so that it oscillated about the line of the trajectory. However, it invariably recovered to a tangential flight, the oscillations reducing in amplitude but when a grenade oscillated it had a much shorter range. The Newton Pippin made a distinctive whistling noise immediately after leaving the barrel when its speed was greatest. When the grenade exploded, fragments were observed to be dangerous at 50 yd but at 75 yd they were harmless. Tests showed that fragments no bigger than a pea embedded themselves in board at a distance of 6 ft.



The drawings from Charles Sangster's rifle grenade patent, 107,893, illustrating its construction.

An ingenious design of rifle grenade was submitted by Charles Sangster who had designed the Pitcher grenade. As with the Pitcher, he patented his invention, obtaining two patents, 107,893 and 124,775, which he applied for in October 1916. The idea behind the grenade was to provide a safe way of arming it in flight that obviated the drawbacks of existing percussion grenades fired from rifles. The body was a streamlined pear shape which ensured that it had a good range. The striker was mounted at the bottom of a thin cylinder on top of which was a propeller-like wind vane. The cylinder had a male screw thread that engaged a female thread in a tube inside the grenade above a percussion cap on the detonator. It was held in a safe position by the ubiquitous pin. When this was removed and the grenade was fired, the passage of air through the blades of the vane turned it so that it unscrewed and the cylinder descended in the tube until it rested on an internal rim just above the cap. When the grenade hit the ground the striker was forced into the cap.

The Sangster underwent troop trials, being designated the No. 25 grenade, but was dropped afterwards, not because it failed to work but because it was not a commercial proposition. To function correctly, the grenade needed to be manufactured within very high tolerances and this was not feasible for something that would have to be manufactured quickly in large numbers.

There were other rifle grenades of the percussion type that failed to make the grade. The No. 17 was one. It was designed by the Royal Laboratory and nicknamed the opera hat grenade because of the appearance of the striker which was topped by a steel disc. The Humphries was another (*see* Chapter 5). The only other rodded percussion-fused rifle grenade to emerge from the war was the No. 39 Stewart pattern (sometimes spelled Steuart). It was first proposed by the Trench Warfare Department in 1917 and underwent severe trials well into 1918 before being finally accepted after some modifications suggested by the Munitions Inventions Department. The No. 39 was too late to be used in anger. It was of a quite different design from other percussion rifle grenades and was intended to overcome the drawbacks of the No. 3 family.

These relied on forward movement of the striker to detonate the grenades so that if they struck muddy or soft ground, there was a slight delay before detonation which allowed their momentum to bury them before they exploded. This severely restricted their effectiveness. As much as half of the fragmentation effect was dissipated in the ground and inevitably a large crater was the result. Moreover, the damage caused to the brass components by the exudation from the explosive when it got damp sometimes made the grenades unsafe to handle. The problem was that the working parts were hidden inside the body so it was impossible to tell what state the grenade was in. The No. 39 had all the mechanism outside the body of the grenade in a cylinder that gave it the appearance of a bottle on a stick. It had an instantaneous fuse and because the mechanism was in the neck of the bottle shape the explosive effect was practically guaranteed to be above ground even if the neck buried itself first.

The rifle grenade was an extremely effective weapon and was often used to suppress German trench mortars. Todhunter reported in 1915 that unless rifle grenades were available for this purpose, some front-line trenches became untenable because of mortar bombardments. They were also useful in eliminating snipers; when one was spotted he might be subjected to a volley, especially from 1916 onwards when rifle grenades were more plentiful than in the early days of the war. All soldiers tended to have a healthy respect for rifle grenades. Germans captured by the French at Ypres in January 1916 told them that 'English rifle grenades do great execution, but the precision of their flight is very much influenced by the elements'. Sometimes batteries of several grenade rifles were rigged up to fire barrages like the one witnessed by Edmund Blunden in 1916, 'sending over by one pull of a cord volleys of half a dozen, which cooed somehow like pigeons as they soared over to do mischief'.

Although all rifle grenades, whether German, French or British, were designed to land head first they did not always do so. Robert Graves had a lucky escape when one landed tail first only feet away from him. It was a chance in a million. Mostly, they were deadly. Frank Richards described an incident when one fell in a bay and killed three of the five men there and wounded the other two. He complained that the British rifle grenade then in service (probably the No. 3) was very poor in comparison.

The rods were usually 15 in or 10 in long, depending on the grenade (although the rodded Mills had one that was only 5.5 in long). For example, the No. 22 and No. 35 had 15 in rods, while the No. 3 and No. 20 had 10 in rods. Range was determined by angle but getting it right was always something of a problem. Experiments with rods of different lengths for the same grenade were not entirely satisfactory. If range was to be determined by rods of specific lengths, the rifle grenadier would inevitably be burdened with extra weight to carry as he would need adequate supplies of rods of each length to give him the full range of options. This was not practical.

Someone had the bright idea of using tightly fitting rubber rings to act as stops so that the rod would only go so far into the barrel before the ring encountered the muzzle and prevented further travel. Preliminary experiments in the summer of 1917 were very promising and arrangements were made to issue a number of rings and range strips to front-line units for trials with 15 in rodded grenades. The results were encouraging and there was a suggestion that the idea could be extended to the 10 in rodded grenades. By late 1917 the rubber ring solution had been adopted. Twenty-five rings were issued for every twenty 15 in rodded grenades. To help grenadiers adjust the rings to the correct position for the desired range, eight range rods were also supplied to each platoon which worked at one per grenadier as there were at that time eight rifle grenadiers per platoon.

Rodded rifle grenades were used for purposes other than dropping high explosive on the enemy's head. There were also smoke and signal grenades and by the end of the war anti-tank grenades as well. There were even occasions when rifle grenades were used to send messages across No Man's Land as recorded by Robert Graves, presumably with the explosive and detonator removed first.

Smoke grenades did not appear until 1916. The smoke was generated by white phosphorus although this also had an incendiary effect. White phosphorus is a pyrophoric incendiary, that is, it spontaneously ignites in the presence of atmospheric moisture. If it touches the skin it can cause serious burns that are difficult to treat because of this property. Since the First World War, its pyrophoric nature has been utilized to ignite other more destructive incendiaries, for example, those based on petroleum products (commonly called napalms although the original napalm was a thickening agent not the thickened fuel itself). The first grenades to use white phosphorus were the No. 26 and the No. 27. The former was a crude device much like the Jam-Tin in appearance being made from a tin cylinder with a time fuse and was intended for the West Spring Gun.

The No. 27 was both a rodded percussion rifle grenade and a hand grenade with a tin body that contained 13.5 oz of white phosphorus. The striker mechanism was brass, including the sleeve and striker which was held in a safe position by a shear wire. Like the egg grenade, the hand-thrown version had to be struck on a hard surface to ignite the fuse before throwing it but when discharged from a rifle the shock of launching it forced back the striker and sheared the wire. Eventually, a Mk II version was produced without a rod, for launching from a cup discharger. The grenade produced an effective smokescreen and was also used to produce air bursts to shower the enemy with white phosphorus. Because of the pyrophoric nature of the white phosphorus, transportation was something of a problem; the bursters, grenades, rods and cartridges all had to be carried in separate boxes.

In 1917 the No. 27 was superseded by the No. 37 which was similar to its predecessor but, as it was intended to be fired from a cup discharger, a steel gas check disc formed the base of the cylindrical grenade. The striker in the first models of the No. 27 were flimsy so for the No. 37 it was redesigned to be machined from solid brass making the latter more reliable and safer.

The smoke grenades were not the first chemical grenades of the war. The patterns of the earliest ones are not clear as they are referred to as No. 1 and No. 2 grenades but it is unlikely that they were modified versions of the explosive percussion grenades with the same numbers. More likely, they were designated as chemical grenades and because they were the first were given the numbers 1 and 2, later to be redesignated because of the inevitable confusion this would cause. Hence, the No. 1 and the No. 2 are most probably the No. 28 Mk I and the No. 28 Mk II (or possibly the No. 29). These were spherical and looked very much like the No. 15 Ball grenade, especially the No. 28 Mk I as this had a similar igniter. It is the

similarity of the igniters, suggesting a safety fuse that had to be lit by a match, that points to this having been introduced in 1915 before the development of automatic igniters like those in the No. 34 Egg grenade. The Mk II had a fuse mechanism that protruded from the top of the grenade like that on the No. 31 signal grenade (they were, in fact, essentially the same). A photograph in the Public Record Office clearly shows a No. 28 Mk I with the date 1915 moulded in the casing.

Chemical grenades contained tear gas such as ethyl iodoacetate or stannic chloride and were mainly used for clearing dugouts. The only other tear gas grenade was the No. 29 which resembled the No. 16 Oval pattern. Whereas the No. 28 started out with a match igniter, the No. 29 had a fuse mechanism like that on the No. 28 Mk II. Designed by the Trench Warfare Department, it was probably a chemical variant of the No. 16.

Signal grenades fired from rifles were introduced in late 1916 with the idea that they might replace mortar signal shells if they proved effective. The grenades, similar to the No. 27, having many interchangeable parts, were the No. 31 day signal grenade and the No. 32 and No. 38 night signal grenades. They were essentially the same except for the fillings. The body consisted of a 7-inch tin cylinder 2.25 inches in diameter which was originally made in two pieces and connected by a bayonet joint. Later, the body was made in one piece with a removable base of stamped tin for filling the grenade. No detonator was used, only a percussion cap and a short length of safety fuse, originally of 2.5 seconds duration but later extended to 3 seconds. The grenades were fired perpendicularly so that they went straight up, the shock of discharge forcing the striker into the cap.

The No. 31 contained a coloured smoke composition. Different colours represented different messages. The No. 32 and No. 38 grenades produced a string of three stars suspended from a parachute, the only difference between them being the colour of the stars. The colours of the No. 32 stars remained the same as they burned whereas the stars in the No. 38 changed colour. Troop trials with star grenades in the summer of 1917 indicated that the grenades might be better if they reached a greater height but were otherwise satisfactory. Nevertheless, 50,000 were ordered in addition to the 50,000 already asked for. A supply of 6,000 a week was also requested. Initially, there were three colour combinations of stars, reading from the top: red, red, red; red, green, red; green, red, green. However, the colour combinations had to be changed periodically as the Germans tended to copy them and sent up fake messages to create confusion.

These rodded signal grenades were replaced in 1918 by similar munitions designed to be fired from discharger cups: the No. 42, No. 43 and No. 45 respectively. These were launched to a height of 350 ft where they were burst by a time fuse. Unlike their predecessors which were made of tin, the grenades were rolled brown-paper cylinders with tin lids held in place with adhesive tape. Each had a wooden base with a tin closure which were pierced by two holes to allow the flash from the launching cartridge to ignite the 3.5-second fuse. When the No. 42 burst, a parachute was dispensed from the paper cylinder, from which a coloured smoke candle was suspended via an asbestos string. The other two grenades used stars instead of the candle.

The anti-tank grenade was an unexpected consequence of the invention of the tank. Although the Germans introduced a big-bore anti-tank rifle firing armour-piercing ammunition to kill the crew, the British went for a more explosive answer to German armour. The anti-tank grenade proved to be more effective, and more durable, than the anti-tank rifle although the British Army was still equipped with one at the outbreak of the Second World War. Many of the German tanks were captured British models which were built with hard steel. The German design, the A7V, was a clumsy monster built with mild steel. The British,

therefore, decided to develop a grenade that was capable of destroying their own tanks and came up with one that was little more than a large tin containing more than 11 oz of alumatol which produced a massive explosion. The benefits of the shaped charge were not to be discovered until about 1940. The grenade, known as the No. 44 anti-tank grenade, had the same percussion mechanism as the No. 35 which allowed detonation to occur on direct contact with the tank. Although this punched a hole in the side of British steel plate it only produced a large bulge in the mild steel of the German tanks. However, this was enough to kill or injure the occupants from the concussion.

Anti-tank engagements took place at close range so the 8 in rod had little time to stabilize the flight of the grenade, thus a calico tail was added to ensure that the grenade flew straight and hit the target squarely. It allowed the grenade to be fired at almost point-blank range and still hit the mark correctly. An improved grenade, the No. 46, was filled with a cast explosive instead of alumatol powder. This increased the explosive power of the grenade and a steel base disc replaced the dished tin one of the earlier grenade so that more explosive could be put into the body. An improved detonator was also developed but the war ended before the grenade could enter service.